PERFORMANCE OF PINEAPPLE LEAF FIBRE AS REINFORCEMENT IN OIL PALM SHELL LIGHTWEIGHT CONCRETE

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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Date : 20 MAY 2019

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Thesis submitted in partial fulfillment of the requirements
for the award of the
B. Eng (Hons.) Civil Engineering

Faculty of Civil Engineering & Earth Resources
UNIVERSITI MALAYSIA PAHANG

MAY 2019

ACKNOWLEDGEMENTS

First, I would like to thank my final year project supervisor, Ir. Dr. Chin Siew Choo for her patience to guide me from beginning until the completion of this Final Year Project. She always sincerely gave me valuable advices, guidance and suggestions even though she was busy but the door to her office was always open whenever I had question about my research. Thanks Dr. Chin for sparing her time to email and tell me all my mistakes in my presentation slide and steered me in the right direction. I truly appreciate the advices she gave.

Secondly, I would like to thank all the lab assistants of Faculty of Civil Engineering for their guidance and assistances during laboratory works. Whenever I needed help, they are always ready to help and try their best to fulfil requirement that needed in my research. I sincerely appreciated their efforts. Without their passionate participation and input, the laboratory work could not have been successfully conducted.

Besides, I would like to express my gratitude to my partner who took almost similar research topic as mine. I am gratefully indebted to him for his helping hands during laboratory works and his very valuable comments on this thesis. Without him, this project probably could not be completed successfully.

Finally, I must express my very profound gratitude to my parents and to my beloved one for their unfailing support and endless motivation throughout the whole process of researching and writing this thesis. This accomplishment would not have been possible without them. Thank you.

ABSTRAK

Konkrit dibentuk oleh agregat kasar yang tertanam dalam matriks simen yang mengisi ruang dan lompang di antara zarah agregat dan melekatkannya bersama-sama. Dalam eksperimen ini, konkrit ringan, yang lebih mampan alam sekitar dibandingkan dengan konkrit konvensional, yang menggunakan sepenuhnya simen. Konkrit ringan lebih mampan alam berbanding dengan konkrit konvensional kerana konkrit ringan mengurangkan penggunaan simen serta kuantiti agregat yang menyebabkan kemusnahan bukit menyebabkan ketidakseimbangan geologi dan alam sekitar. Konkrit konvensional adalah bahan rapuh di mana retakan struktur akan dikembangkan walaupun sebelum beban digunakan kerana kekuatan tegangan yang rendah, kemuluran terhad, dan sedikit ketahanan terhadap retak. Beban luaran akan menyebabkan penyebaran lebih banyak keretakan yang sedia ada dan akhirnya menyebabkan keretakan konkrit dan keretakan tambahan yang baru terbentuk. Oleh itu, kemasukan tetulang dalam konkrit adalah diperlukan. Gentian biasanya digunakan dalam konkrit untuk mengawal penyebaran retakan mikro, pengecutan dan untuk meningkatkan kekuatan dan prestasi konkrit. Dalam penyelidikan yang lalu, kerana pertimbangan ancaman terhadap alam sekitar, serat mesra alam diperkenalkan kepada bidang konkrit sebagai sumber alternatif serat yang akan digunakan dalam konkrit untuk meningkatkan sifat mekaniknya. Kajian utama ini adalah untuk menumpukan kepada kelakuan mekanikal serat daun nanas (PALF) dalam konkrit ringan sawit kelapa sawit dalam pecahan volum serat yang berbeza kepada jumlah konkrit 0.5 %, 1 %, 1.5 % dan 2.0 % daripada PALF berbanding dengan konkrit biasa . PALF diekstrak dan kemudian dirawat dengan natrium hidroksida dengan kepekatan 10% untuk meningkatkan ketahanan serat. Dalam kajian ini, panjang PALF dibuat berterusan sebanyak 40mm berdasarkan panjang gentian optimum dari penyiasatan sebelumnya. Ujian eksperimen dalam kerja ini termasuk ujian kemerosotan, ujian kiub, ujian lenturan empat mata dan ujian tegasan pemisahan yang terdiri daripada 60 kiub, 15 rasuk dan 15 silinder. Kubis konkrit diuji pada umur sembuh 3, 7, 14 dan 28 hari, manakala bagi silinder dan rasuk hanya perlu diuji pada 28d. Proses pengawetan air yang berterusan telah dijalankan untuk semua kiub, silinder dan sampel rasuk untuk tempoh yang diperlukan. Dari pelbagai hasil ujian, prestasi konkrit biasa dan sifat konkrit ringan dan mekanikal gentian konkrit bertetulang serat minyak kelapa sawit telah disahkan. Penyelidikan menunjukkan bahawa kekuatan mampatan menurun pada semua peringkat umur dengan peningkatan pecahan pecutan PALF, manakala kekuatan tegangan dan kekuatan lenturan yang berpecah memberikan hasil yang positif dengan sedikit penambahan serat. Kemasukan PALF meningkatkan kekuatan tegangan dan lenturan sehingga 3.28 MPa dan 6.55 MPa masing-masing. Berbanding dengan campuran kawalan 0 %, apabila serat meningkat kepada 1 %, kekuatan lenturan dan kekuatan tegangan meningkat sehingga 36.32 %. Dari hasil yang diperoleh, 1.0 % PALF adalah nisbah volum serat optimum untuk pembangunan kekuatan tegangan dan lentur. Dari segi kebolehmampuan, penambahan PALF dalam campuran konkrit secara drastik menurunkan kebolehkerjaan konkrit yang baru dicampur dengan air serat yang diserap. Oleh itu, dapat disimpulkan bahawa PALF sesuai untuk digunakan dalam konkrit ringan, namun tidak sesuai untuk menghasilkan konkrit ringan yang tinggi.

ABSTRACT

Concrete is formed by coarse aggregate embedded in the cement matrix which fills the spaces and voids among the aggregate's particles and glue them together. In this experiment, lightweight concrete, which is more environmentally sustainable as compared to conventional concrete, which fully using cement was studied. Lightweight concrete is more environmentally sustainable as compared to conventional concrete because lightweight concrete reduces usage of cement as well as quantities of aggregates which results in destruction of hills causing geological and environmental imbalance. Conventional concrete is relatively a brittle material where the structural cracks will be developed even before loadings are applied due to its low tensile strength, limited ductility, and little resistance towards cracking. The external load will lead to further propagation of existing cracks and eventually caused spalling of concrete and the newly formed additional cracks. Hence, inclusion of reinforcement in concrete is necessary**.** Fibres are commonly used in concrete to control the propagation of micro cracks, shrinkage and to improve the strength and performance of concrete. In the past researches, due to consideration of threat to the environment, eco-friendly fibre is introduced to the field of concrete as an alternative source of fibre to be used in concrete for increasing its mechanical properties. The highlight of this research is to focus on the mechanical behaviour of pineapple leaf fibre (PALF) in oil palm shell lightweight concrete in different fibre volume fractions to concrete volume 0.5%, 1.0%, 1.5% and 2.0% of PALF compared to plain concrete. PALF was extracted and then treated with sodium hydroxide with concentration of 10% to enhance fibres durability. In this research, the length of PALF was made constant as 40 mm based on optimum fibre length from previous investigations. The experimental testing in this work include slump test, cube test, four-point bending test and splitting tensile test which comprises of 60 cubes, 15 beams and 15 cylinders. The concrete cubes were tested at the curing age of 3, 7, 14 and 28 days, whereas for cylinder and beam were tested at 28 days. Continuous water curing process was conducted for all cubes, cylinders and beams samples for the required period. From the various test results, the performance of plain concrete and lightweight concrete and mechanical properties of fibre reinforced oil palm shell lightweight concrete were evaluated. The research showed that the compressive strength decreased at all ages with an increase in PALF volume fraction, whereas splitting tensile strength and flexural strength give positive result those with a small amount of fibre addition. The inclusion of PALF increase the tensile and flexural strength up to 3.28 MPa and 6.55 MPa respectively. Compared to the control mix 0%, when the fibre increase to 1.0%, the flexural strength and tensile strength increase up to 36.32%. From the results obtained, 1.0% PALF is the optimum fibre volume ratio for tensile and flexural strength development. In terms of workability, the addition of PALF in concrete mix drastically decreased the workability of freshly mixed concrete as the fibre absorbed water greatly. Hence, it can be concluded that PALF is suitable to be used in lightweight concrete, however not suitable to produce high strength lightweight concrete.

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LIST OF SYMBOLS

%	Percentage
mm	Millimetre
MPa	Mega Pascal
kg	Kilogram
kg/m^3	Kilogram per cubic metre
N	Newton
^oC	Degree Celsius
kN	kilo Newton
kN/s	kilo Newton per second
^oC	Degree Celcius

LIST OF ABBREVIATIONS

PALF	Pineapple leaf fibre
ASTM	American Society for Testing and Materials
FRC	Fibre-reinforced concrete
Vf	Volume fraction
PALF	Pineapple leaf fibre
OPC	Ordinary Portland Cement
OPSLWC	Oil palm shell lightweight concrete
SSD	Saturated surface dry
UTM	Universal Testing Machine
HSLWC	High strength lightweight concrete
NaOH	Sodium Hydroxide

CHAPTER 1

INTRODUCTION

1.1 Research Background

Concrete is formed by coarse aggregate embedded in the cement matrix which fills the spaces and voids among the aggregate's particles and glue them together. In this experiment, lightweight concrete which is more environmentally sustainable as compare to conventional concrete which fully using cement is used. Lightweight concrete is more environmentally sustainable as compare to conventional concrete because lightweight concrete reduces usage of cement as well as quantities of aggregates which results in destruction of hills causing geological and environmental imbalance. In this research, the main purpose of investigate lightweight concrete because lightweight concrete has lower strength as compare to conventional concrete, we want to investigate by addition of fibre composite can enhance lightweight concrete strength until which extent.

Plain concrete is a relatively brittle material where the structural cracks will be developed even before loadings are applied due to its low tensile strength, limited ductility, and little resistance towards cracking. The external load will lead to further propagation of existing cracks and eventually caused spalling of concrete and the newly formed additional cracks. Hence, inclusion of reinforcement in concrete is necessary. A French gardener by name Joseph Monier first invented the reinforced concrete in the year 1849. Fibres are commonly used in concrete to control the propagation of micro cracks, shrinkage and to improve the strength and performance of concrete. Portland cement concrete is weak in tension loading while strong in compression loading whereas reinforced concrete is strong in compression loading as well as tension loading.

Therefore, eco-friendly fibre is introduced to the field of concrete to enhance its tensile capacity.

Egyptians has developed the concept of using fibres in the concrete mix as one of a reinforcing materials before they used to mix the straw and hairs of animals in the concrete as a material of reinforcement. (Mahesh and Kavitha, 2016). Natural fibre based composites are under intensive study due to their eco-friendly nature, peculiar properties, huge and wide range availability, easy and safe handling due to their flexibility, and biodegradable nature. From the socioeconomic prospective, PALF can be a new source of raw material to the industries and can be potential replacement of the expensive and non-renewable synthetic fibre.

In the past researches, due to consideration of threat to environment, researchers have used plant fibres as an alternative source of steel and/or artificial fibres to be used in composites (such as cement paste mortar and/or concrete) for increasing its strength properties. (Kavitha & Dr. T Felix 2017) These plant fibres, herein referred as natural fibres, include coir, sisal, jute, pineapple leaf, kenaf, abaca leaf, bamboo, palm, banana, hemp, flax, cotton and sugarcane.

Pineapple leaf fibre (PALF) is one of the fast-growing plants and abundantly available wastes materials of Malaysia as compared to other natural fibre which are less productive. Hence, PALF has gained stimulants as an alternative to substitute synthetic fibres. Their use can lead to sustainable development. Since they are waste material, make use of them can reduce landfill consumption, environmental containment as well as reduce cost to manage them. Synthetic (chemically produced) fabrics are made by joining monomers into polymers, through a process called polymerization. Examples of synthetic fabrics include polyester, acrylic, nylon and rayon. They were costly and have an impact on environment as it is not biodegradable. Rayon is artificial silk that made from wood pulp. The sustainable supply of PALF can reduce the pressure on forest and agriculture.

1.2 Problem Statement

The major disadvantage is that concrete develops micro cracks during curing. It is the rapid propagation of these micro cracks developed in plain concrete easily under applied stress basically due to drying shrinkage. Plain concrete possesses a very low

tensile strength, limited ductility and low resistance towards cracking especially lightweight concrete where its compressive and flexural strengths reduce with its density hence need some reinforcement in it. Concrete in service thus cracks easily and this cracking creates easy access routes for deleterious agents resulting in early saturation, freeze-thaw damage, scaling, discoloration and steel corrosion. To overcome this problem, various types of fibre composites were added into cement matrix to enhance the crack control and also concrete strength. In this research, natural fibre composite is used instead of synthetic fibre as synthetic material which are by-products of petroleum are non-biodegradable, synthetic products take a long time to decompose, creating long-term pollution. Nylon is hard to recycle, making them hard to decompose, accumulate landfills more. Besides, addition of steel fibre in concrete although can reduce micro cracks propagation but steel have high probability to corrode once it exposes to environment causing it to lose bonding capability in concrete.

1.3 Research Objectives

The objectives of the research are as follows:

i. To determine the physical properties (workability) of OPS lightweight concrete

ii. To determine the mechanical properties (compression test, flexural test and split tensile test) of OPS lightweight concrete with 0.5%, 1.0 %, 1.5 %, and 2.0 % of pineapple leaf fibre

iii. To validate the performance of plain concrete and OPS lightweight concrete

1.4 Scope of Research

The highlight of this research is to focus on the mechanical behaviour of PALF in oil palm shell lightweight concrete in different fibre content (fibre volume ratio to concrete volume ratio) as compared to plain concrete. PALF is a product extracted from pineapple leaf which is easily available in the states of Johor, Sarawak, Sabah, Kedah, Selangor, Penang, and Kelantan. These fibres extracted are then treated with sodium hydroxide with the optimum concentration of 10 % to enhance fibre durability. In this research, the length of PALF is made constant based on fibre optimum length to

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